"The journey to zero carbon homes" - Monday 19 April

Some notes about a new-build zero carbon house by David Searle

Origins

1) I have had green interests for as long as I can remember, going back to a "Dig for Victory" allotment, tended by my father, on the site now occupied by ?Abbey Cottage?, in front of Montfort Cottage overlooking the Abbey Fields, which is where I was raised. An interesting coincidence is that George Martin, who is giving the following talk on upgrading an existing house, subsequently lived there as well. My father also inspired me by building a bungalow to downsize for his retirement, working well ahead of the building regulations of the time with better insulation and minimised air leaks. So when Sue and I decided to downsize, we looked around the Kenilworth area, but couldn't find anything suitable. Several years of agonising about the best way of "greening" our old house, led us to believe that knocking it down, and selling off half the land would be the only financial and practical way to arrive at a very low carbon house.

2) How green should we be? Basically as green as we could afford! The first thing was to do a lot of research. While browsing the bookshop at the Centre for Alternative Technology, near Machynlleth, I found "The New Autonomous House" by Brenda and Robert Vale. It instantly struck a chord. Their actual house was completed in November 1993. So there is no really new technology in our house, just more up to date versions. The book discusses not only possible solutions to the idea of an autonomous house, with no mains connections, but the reasoning behind each decision.

Our Choices

1) The first choice of all was specify the basic shell. Should we use dense or lightweight construction: Thermal mass and temperature stability, using poor environmental materials versus better environmental materials, but the possibility of a need for air conditioning in potentially increasingly hot summers. We chose the former, so low running energy won over low embodied energy. There are technologies available to simulate increased thermal mass, in a lightweight construction, but they are relatively costly.

2) Insulation: at least double the commonly used levels.

3) Airtightness and ventilation: As soon as you decide to go for a really well sealed house, trickle vents in windows become ridiculous, so a proper ventilation system is required.

4) After the basic shell was decided, each additional subsystem had to have a payback at the then current interest rates (5%). i.e. It had to have a cost saving in excess of the loss of interest on the capital cost. In effect our income in retirement had to be better than it would have been without the system. The actual payback period was not uppermost in our minds. All of these decisions were taken with the expectation that energy costs were necessarily on a long term upward trend, and that would also reflect in any services we used. This meant that any investment that was found to be marginal, had the probability of becoming respectable in the near future. As it happened the oil price spike and greatly reduced interest rates have sharply tipped the balance in our favour.

Implementation

Watching the build can give you the screaming hab dabs! I must have a vivid imagination, I could see air leakage paths and cold bridges and gaps in insulation everywhere. I was not a favourite with the brickies. However I was blessed with a very helpful and tolerant builder – Dave Williams – who even came to the Ecobuild show with me to see what was what.

1) With brick and block construction: the devil is in the detail. Walls of 450mm thickness require wider trench fill foundations. 250mm cavities require special wall ties, cavity closers and trays. The ground floor was to have been a conventional concrete slab, but the ground conditions

dictated a late change, so that both floors were beam and block. The stub walls below the ground floor were all lined with 50mm of foil faced polyisocyanurate (or PIR) insulation to reduce the cold bridge. Wall ties were a saga all in themselves. We wanted glass reinforced polyester ties, for thermal conductivity reasons, but the Danish supplier to Brenda and Robert Vale had gone out of business. Finally I found a two part stainless steel tie at a cost of £1.76 compared with a conventional butterfly tie at just 19p! We ordered 1000 ties, and 5 days after delivery, I received an email suggesting a basalt reinforced resin tie at £1.22. The advantage was not only cost, but a negligible thermal conductivity. The fat stainless steel ties can allegedly reduce the U values by around 12% compared with the reinforced resin variety. That is roughly equivalent to needing an extra 50mm of mineral wool in the cavity. The actual insulation material is the cheap bit. We also chose to have dense concrete block partition walls throughout to enhance the thermal mass There are no studding partitions in the house at all, even for built in wardrobes.

2) Insulation: the 250mm wall cavities were filled with mineral wool, which gave a U value of 0.14. The ground floor was laid on two 80mm thicknesses of Quintherm foil faced (PIR), finished with 90mm of screed, this gave an overall U value of 0.11. The roof space was filled with 500mm of Warmcel, blown into place. We wanted attic trusses to allow for a room in the roof if required at a later date. This gives complications if you want 500 mm of insulation, as the depth of the truss floor beams is much less. The design dealt with this by having a false ceiling suspended from the attic trusses to give the required depth. This was lined with a polythene vapour barrier, sealed to the blockwork. This gave a U value of 0.08.

3) Airtightness: Here you need to use your imagination and lots of foam and silicone. To achieve a good seal the walls were wet plastered throughout, as plasterboard on dabs may be airtight to the rooms, but probably won't be to the floor spaces, and anyway will allow cold air behind the plasterboard from the mortar gaps in the blockwork. The vapour barrier in the first floor ceiling was not allowed to be penetrated by any services except at a single place by a 100mm service pipe, later filled with foam. This was assisted by a false ceiling on both floors to accommodate the heat recovery ventilation ducting, so no wires had to go into the attic, except via the service pipe. We achieved an air permeability value 2.26 $m^3/h.m^2$, which is better than twice as good as conventional houses on the same site built by the same builder, and roughly four times as good as the building regulations require.

4) Once the building is designed to be airtight, controlled ventilation is necessary, and a heat recovery ventilation system was specified. This extracts air from the warm, wet, and smelly areas, (bathrooms toilets, kitchen, and utility room), passes it through a heat exchanger, where it warms up the incoming fresh air for distribution to all the habitable rooms. The stale air is then ducted outside after the majority of its heat has been reused. The system has proved excellent. It has helped in the distribution of warmth around the house. A crude test was carried out on a freezing day, when the inside temperature was 19 deg. C., the fresh air inlets were delivering at 17 deg. C. We have made one alteration from the recommended ducting arrangements, and that is to provide an additional extract point for warm air from over the woodburner.

5) The decision in the autonomous house to have a composting toilet was very much in my line of thinking, as a long term organic gardener, but common sense prevailed, purely from a house resale point of view. When we have popped our clogs, we didn't want our children to have the difficulty of persuading a potential buyer that a composting toilet was a good thing to have in Malthouse Lane, however practical and effective in reality. The Vales had no mains water or sewage connection and used rainwater harvesting on a massive scale (30,000 litres, or 30 tonnes) to provide all washing and drinking water. It is remarkable that during the 1995 drought, when the chairman of Yorkshire Water claimed he hadn't had a bath in months, they had two thirds of their capacity still in store when the drought broke, having used no special conservation measures. Although we chose to use mains water, rain water harvesting did seem sensible for use in the toilets, and the washing machine. It has provided a few niggles but is now working well. Firstly the groundworkers buried the tank too deeply, encasing it in concrete, instead of the recommended sand. The result was that the overflow was below the level of the ground water in winter. It proved unlikely that it could be raised without damage, so a second tank had to be installed at the correct depth. So I now have a well with 3500 litres capacity, as well as a proper rainwater harvesting tank!

6) Heating is a major issue in any house, and a tricky one to get right in a low carbon house. The calculations suggest a total steady state requirement of around 3Kw so that central heating is not really required. Waste heat from computers, fridges, cooking, lighting and the body heat of

the occupants etc. will provide a base level, so space heating top up and water heating become the issue. Initially we chose a woodburner with a back boiler, which was the only one approved for use in a smokeless zone. However availability became worse and worse owing to demand and a six week lead time eventually was quoted at 25 weeks. As this was holding up the entire project, we chose to use a woodburner without back boiler, of which there are many approved designs. Then we would use the immersion heater to back up the solar hot water.

We then realised that the original choice of woodburner was mistaken anyway, as the heat output was optimised for several radiators, and would have been completely over the top for domestic hot water purposes. The final specification is a 6Kw woodburner (a Stanford 23 from Euroheat.), with a 2Kw flue boiler which is an add on to replace the first metre of the flue.

Solar gain is not of great significance on the site, as the house faces east-west, with the southern aspect blocked by neighbouring houses, but the glazing was clearly important. We searched the market very thoroughly, having ruled out PVC on environmental grounds from the start. We found treated softwood windows with average U values around 1.4. We looked at triple glazing, but found that the saving on a zero deg. C day would only be 230 watts for the entire house, at a premium of £2500, it didn't add up. At –30 deg C it might have been justifiable!

I have to say this is the most comfortable house I have ever lived in. As it is, all we have to do is light the woodburner, if the living room temperature is below 18 deg. C. It takes less than 5 minutes, and we refuel until the room is above 21 Deg. C., or bedtime, whichever is sooner. After a centrally heated house where you are watching the pennies by using a time clock, zone control valves, radiator thermostatic valves etc. it is bliss to just let the entire house warm up fully, and to find that every part of it is at a comfortable temperature all the time. The effect of large thermal mass, and a total absence of cold rooms or draughts is a novel experience. As it is we are totally independent for our house heating and hot water in winter, for the inconvenience of carrying logs and ashes.

Finally, our cooking is all electric, with conventional and fan ovens, plus a microwave, and an induction hob. This latter is absolutely magic, it is the most efficient of hobs, with instant controllability, just like gas.

The solar water heating has had a few teething problems, down to the fact that the thermal store chosen had an unusual method of delivering domestic hot water which churned up the tank contents destroying the stratification between cold water and hot water. This fooled the solar control sensors into not starting the pump because the roof temperature had to be much higher to be able to deliver any heat to an already hot tank. A new control method seems to have made an improvement, but time will tell. The problem stemmed from the need for the design of heat store to accommodate immersion heater, woodburner, solar, and domestic heating offtakes all into one tank. The domestic heating circuit is only used for the towel rails in the bathrooms.

7) Solar electricity – other than bureaucratic problems, this has worked well from the start, and as I write is producing 1.1Kw. It has a peak rated output of 2.62Kw. There are many tariff combinations possible to recover the Renewables Obligation Certificates (ROCs), and the one we have chosen is to assign them to Southern Electric in return for any of their standard tariffs, and to be credited with 28p per unit exported to them.

Well that wraps up our project. I'm afraid there is a lot of stuff to absorb, as we have had to integrate many systems to arrive at a home that has a SAP rating of A for Environmental impact, with –0.2 tonnes of CO_2, i.e. better than zero carbon. We are a bit miffed to find that it seems impossible to achieve an A rating for Energy efficiency if you use a woodburner as your primary heat source. Maybe the rating system needs adjusting!

All in all it has been a most exciting project, and we have learnt a lot.

David Searle 2010